Environmental Contaminants in American and Arctic Peregrine Falcon Eggs in Alaska, 1979-95

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May 31, 2000

Executive Summary

Arctic and American peregrine falcons (*Falco peregrinus tundrius* and *F. p. anatum*) were listed as endangered under the Endangered Species Preservation Act (1969) in 1970, and later, in 1973, under the Endangered Species Act. At the time of listing, some local populations of American peregrine falcons in the eastern United States had disappeared, and populations in western and northern North America had been reduced by 80 percent or more. Organochlorine pesticides such as DDT and its breakdown product DDE were identified as the cause of the decline. The peregrines accumulated these chemicals in their tissues by feeding on birds that had eaten DDT-contaminated insects or seeds. These chemicals prevented normal calcium deposition during eggshell formation, and caused females to lay thin-shelled eggs that often broke before hatching. The use of DDT was restricted in the United States and Canada in the early 1970s, and by the late 1970s, populations of peregrine falcons were beginning to recover.

After Arctic and American peregrine falcons were listed, recovery plans for four different geographic areas were prepared. For the Alaska populations, the Recovery Plan identified specific ““index”” areas (areas representative of interior and northern Alaska) to survey, and specific recovery criteria that needed to be achieved prior to reclassification. These criteria included number of pairs occupying territories, number of young produced, amount of DDE residue in eggs, and eggshell thickness for each of the index areas.

Since 1979, the U.S. Fish and Wildlife Service has monitored environmental contaminants in American peregrine falcon and arctic peregrine falcon eggs in interior and arctic Alaska. Monitoring goals were collection and analysis of a minimum of 10 eggs from each subspecies every five years. The results of the 1984 program were reported by Ambrose et al. (1988a); this paper reports on 1988-95 analyses and compares data across the entire time span (eggs from 89 *F. p. anatum* and 68 *F. p. tundrius* nests from interior and northern Alaska collected between 1979 and 1995). In most cases a single egg was removed from each nest. More than one egg was collected from 23 nests, and contaminant values for those eggs were averaged for the nest. The majority of eggs analyzed were addled and collected during visits to band nestlings, but fresh eggs were collected during incubation in 1984, 1989, and 1995. Multiple eggs were taken from five females at intervals of two to four years. Four females with known wintering locations (via satellite tracking) were sampled, as were 33 eggs from known or estimated-age females.

Organochlorine (OC) contaminants were measured from 1979-95, and data were adjusted for moisture loss associated with development. Metals and trace elements (metals) were measured from 1988-95. We performed statistical analyses (hypothesis testing) for analytes that were consistently detected and consistently measured over the study period (1979-95 for OCs; 1988-95 for metals). These included p,p'-DDE, dieldrin, heptachlor epoxide, oxychlordane, and total PCBs; and copper, iron, magnesium, mercury, and zinc. Summary statistics were generated for other analytes depending upon the percent detections (geometric mean, range, and percent detection). We used general linear models to test OC and metal concentrations for changes in contaminant concentrations over time, differences between the American and arctic subspecies, differences between fresh and addled eggs, differences between eggs from successful and unsuccessful nests, and the relationship of eggshell thickness with DDE. There were significant declines over time for all OCs, although the trend was weaker for total PCBs than for other OCs. Copper, iron, and zinc significantly declined over time; magnesium and mercury did not. Because there were significant changes over time, a time factor was incorporated into subsequent analyses. Dieldrin was significantly greater and p,p'-DDE was significantly lower in *F. p. tundrius* compared to *F. p. anatum* over the entire study period; no other contaminants were significantly different between subspecies, although *F. p. anatum* had generally greater concentrations overall. Because of these differences, and because the subspecies are managed separately, we separated subsequent analyses by subspecies.

There were no significant differences in OC concentrations between fresh and addled eggs, for either subspecies. For *F. p. anatum*, iron and zinc were significantly greater, and magnesium was significantly lower, in fresh eggs compared to addled. There were no differences in metal concentrations between fresh and addled eggs for *F. p. tundrius*. For *F. p. anatum*, dieldrin, oxychlordane, and total PCBs were significantly greater in eggs from unsuccessful nests compared to successful nests, as were copper, iron, and mercury. There were no differences in eggs between unsuccessful and successful nests for *F. p. tundrius*.

There were no significant differences in eggshell thickness between subspecies, between fresh and addled eggs, or between eggs from successful compared to unsuccessful nests. There was no significant increase in eggshell thickness over time, although thickness appeared to increase slightly. Eggshell thickness was significantly negatively correlated with p,p'-DDE concentrations. Mean eggshell thicknesses from 1991-95 were 12.0 and 10.6% thinner (*F. p. anatum* and *F. p. tundrius*, respectively) than pre-DDT era peregrine eggs.

Analytes that weren't consistently measured or consistently detected over the study period (1979-95 for OCs, 1988-95 for metals), but that were found in >50% of the samples in which they were analyzed, included beta-BHC, p,p'-DDD, p,p'-DDT, HCB, mirex, trans-nonachlor, manganese, selenium, strontium, and tin. Concentrations of these and the ten analytes used for hypothesis testing were compared to several published thresholds for reproductive effects, and the only contaminant exceeding these thresholds at any time was mercury. Additionally, the percent of mercury concentrations exceeding effect thresholds increased over time.

Although both OC and contaminant concentrations have decreased over time, evidence for cumulative and single-contaminant reproductive effects were found. Further, mercury remains a contaminant of continuing concern due to increasing concentrations and toxic reproductive effects. Contaminant monitoring remains a necessary management tool because peregrine falcons are still recovering from near extinction caused largely by environmental contaminants, and because they are top predators that remain vulnerable to persistent and bioaccumulative compounds.